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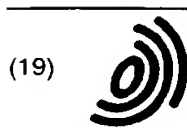
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(54) **Gear lubricating oil composition**

(57) A gear lubricating oil composition comprising a base oil of lubricating viscosity having dissolved or dispersed therein an alkali metal borate or a hydrate thereof in an amount of 0.04 to 1.0 wt % in terms of boron content, an oil-soluble sulfur-containing extreme pres-

sure agent in an amount of 0.01 to 5.0 wt % in terms of sulfur content, an oil-soluble phosphorus-containing extreme pressure agent in an amount of 0.001 to 1.0 wt % in terms of phosphorus content, and a zinc dialkyldithiophosphate in an amount of 0.01 to 1.0 wt % in terms of phosphorus content.

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**Description**

[0001] The present invention relates to a novel gear lubricating oil composition. The novel gear lubricating oil composition comprises an alkali metal borate or hydrate thereof, an oil-soluble sulfur-containing extreme pressure agent, an oil-soluble phosphorus-containing extreme pressure agent and a zinc dialkyldithiophosphate. This unique combination of compounds provides improved extreme pressure and antiwear performance, especially at high temperatures, in gears.

**BACKGROUND OF THE INVENTION**

[0002] Hitherto, various lubricating oils have been used to lubricate friction parts of internal combustion engines and machine tools. Previously, lubricating oils were composed of only a base oil component such as mineral oil and vegetable oil or fat, but many sorts of additives have been developed and are used currently because a variety of functions have been required for preparing lubricating oils. Therefore, most of the lubricating oils used now are lubricating oil compositions containing additives dispersed or dissolved in base oil.

[0003] A gear lubricating oil (gear oil), which lubricates gears of machine tools or motor cars, also contains various additives for improving lubricity or heat resistance. Recently, gears of vehicles such as motor cars driven at a high speed have been increasingly used. These gears must be made small, in consideration of transmission torque in view of setting space. Accordingly, they often bear high contact pressure, and hence high lubricity and excellent heat resistance are particularly required of a gear oil for those gears. In fact, gear oils containing sulfur-containing extreme pressure agents or phosphorus-containing extreme pressure agents (which are together called "SP extreme pressure agents") have been generally used. However, even the gear oils containing SP extreme pressure agents can not fully lubricate the gears of recent motor cars, which are driven under severe conditions. For example, since the gears of recent motor cars are usually set in a closed system, a lubricating oil for the gears (a gear lubricating oil) is liable to increase its temperature to a higher level. The lubricating oil at a high temperature often causes unstable working of the gears.

[0004] Further, if the gear lubricating oil is used at a high temperature for a long time, it typically deteriorates.

[0005] Accordingly, various gear lubricating oil compositions have been hitherto proposed with the intention of improving heat resistance.

[0006] Japanese Patent Provisional Publication No. 5-209184 discloses a gear oil composition for motor cars. The composition improves anti-seizure properties, thermal stability and high temperature-oxidation stability. This composition comprises a sulfur or phosphorus extreme pressure agent, an alkali metal borate hydrate, and a polyester or an ether such as polyol ester or polyoxyethylene alkylether.

[0007] Japanese Patent Provisional Publication No. 6-192674 also discloses a gear oil composition for motor cars. The composition provides improved anti-seizure, oxidation stability and friction properties. This composition comprises a sulfur or phosphorus extreme pressure agent, an alkali metal borate hydrate and an aliphatic or aromatic carboxylic acid or an ester thereof.

[0008] Japanese Patent Provisional Publication No. 6-200269 discloses a gear oil composition that is useful for wet brakes. The composition comprises an alkali metal borate hydrate, a zinc dialkyldithiophosphate and an a friction modifier instead of a sulfur or phosphorus extreme pressure agent.

[0009] Japanese Patent Provisional Publication No. 6-220475 discloses a gear oil composition comprising an alkali metal borate hydrate, an organic molybdenum compound, and a phosphoric ester or hydrocarbon sulfide.

[0010] Japanese Patent Provisional Publication No. 6-256783 discloses a gear oil composition for motor cars. The composition improves thermal stability and oxidation stability. This composition comprises an alkali metal borate hydrate, a zinc dialkyldithiophosphate, and a polyester or an ether such as polyol ester or polyoxyethylene alkylether.

[0011] Japanese Patent Provisional Publication No. 7-258674 discloses a gear oil composition for motor cars. The composition can lubricate both manual change gears and final reduction gears equipped with Limited Slip Differential (LSD), and provides improved extreme-pressure properties, antiwear properties, synchronizing properties, oxidation stability and LSD performance. This composition comprises a sulfur or phosphorus extreme pressure agent, an alkali metal borate hydrate, and a detergent-dispersant of alkaline earth metal type.

[0012] Japanese Patent Provisional Publication No. 9-132790 discloses another gear oil composition for motor cars that can lubricate both manual change gears and final reduction gears. The composition comprises a base oil having a particular kinetic viscosity, a sulfur or phosphorus extreme pressure agent, an alkali metal borate hydrate in an amount less than that of the extreme pressure agent, and a zinc dialkyldithiophosphate in an amount less than that of the extreme pressure agent. This composition provides improved extreme-pressure properties, anti-pitching properties, synchronizing properties, oxidation stability, anti-sludge properties, and storage stability.

[0013] U.S. Patent Number 4,717,490 discloses an alkali metal borate-containing lubricating oil containing an alkali metal borate, an oil-soluble sulfur compound, a dialkyl hydrogen phosphite, and a mixture of neutralized phosphates,

said phosphates being essentially free of monothiophosphates which provides a lubricant with superior load-carrying properties.

## SUMMARY OF THE INVENTION

**[0014]** It has now been found that a gear lubricating oil composition containing an alkali metal borate or hydrate thereof, an oil-soluble sulfur-containing extreme pressure agent, an oil-soluble phosphorus-containing extreme pressure agent and a zinc dialkyldithiophosphate provides surprisingly improved antiwear capacity, especially at high temperatures, thus reducing wear on the gears commonly found, for example, in transmissions, axles, trans-axles and industrial machinery, such as stationary gear boxes.

**[0015]** In its broadest embodiment, the present invention relates to a gear lubricating oil composition comprising:

- a) a major amount of a base oil of lubricating viscosity,
- b) 0.04 to 1.0 wt % in terms of boron content of an alkali metal borate or hydrate thereof,
- c) 0.01 to 5.0 wt % in terms of sulfur content of an oil-soluble sulfur-containing extreme pressure agent,
- d) 0.001 to 1.0 wt % in terms of phosphorus content of an oil-soluble phosphorus-containing extreme pressure agent, and
- e) 0.01 to 1.0 wt % in terms of phosphorus content of a zinc dialkyldithiophosphate.

**[0016]** In the gear lubricating oil composition or in the gear oil additive concentrate of the present invention, the boron content of the alkali metal borate or hydrate thereof preferably is not less than 1/10 by weight, based on the sulfur content, of said oil-soluble sulfur-containing extreme pressure agent.

**[0017]** The present invention also relates to a gear oil additive concentrate containing a diluent and the gear lubricating oil composition of the present invention.

**[0018]** A minor but effective amount of the gear oil additive concentrate of the present invention may be incorporated into a major amount of lubricating oil to improve the high temperature antiwear performance by the gear lubricating oil composition.

**[0019]** This invention further provides a method of producing the gear lubricating oil composition of the present invention by blending a mixture of a major amount of a base oil of lubricating viscosity and effective amount of an alkali metal borate or hydrate thereof, an oil-soluble sulfur-containing extreme pressure agent, an oil-soluble phosphorus-containing extreme pressure agent and a zinc dialkyldithiophosphate to improve the high temperature antiwear properties.

## DETAILED DESCRIPTION OF THE INVENTION

**[0020]** The gear lubricating oil composition of the present invention comprises a major amount of a base oil of lubricating viscosity, an alkali metal borate or a hydrate thereof, an oil-soluble sulfur-containing extreme pressure agent, an oil-soluble phosphorus-containing extreme pressure agent and a zinc dialkyldithiophosphate.

**[0021]** The gear lubricating oil composition of the invention mainly comprises the following additive components dispersed or dissolved in a base oil:

- a) a major amount of a base oil of lubricating viscosity,
- b) an alkali metal borate or a hydrate thereof in an amount of 0.04 to 1.0 wt % in terms of boron content,
- c) an oil-soluble sulfur-containing extreme pressure agent in an amount of 0.01 to 5.0 wt % in terms of sulfur content,
- d) an oil-soluble phosphorus-containing extreme pressure agent in an amount of 0.001 to 1.0 wt % in terms of phosphorus content, and
- e) a zinc dialkyldithiophosphate in an amount of 0.01 to 1.0 wt % in terms of phosphorus content.

**[0022]** Each additive component used in the gear lubricating oil composition of the present invention is prepared by reaction of known materials in an organic solvent (e.g., a petroleum component or synthetic oil component similar to the base oil). The solvent may be partly removed by evaporation after the reaction, if needed, and thereby the additive component can be obtained in the form of a concentrated solution or dispersion. The concentration of each component slightly varies according to the nature of the component, and hence in this specification the concentration of each component is described in terms of boron, sulfur or phosphorus content (wt %).

Base Oil of Lubricating Viscosity

[0023] The base oil of lubricating viscosity used in such compositions may be mineral oils or synthetic oils of viscosity suitable for use in gears. The base oils may be derived from synthetic or natural sources. Mineral oils for use as the base oil in this invention include, for example, paraffinic, naphthenic and other oils that are ordinarily used in lubricating oil compositions. Synthetic oils include, for example, both hydrocarbon synthetic oils and synthetic esters and mixtures thereof having desired viscosity. Useful synthetic hydrocarbon oils include liquid polymers of alpha olefins having the proper viscosity. Especially useful are the hydrogenated liquid oligomers of C<sub>6</sub> to C<sub>12</sub> alpha olefins such as 1-decene trimer. Likewise, alkyl benzenes of proper viscosity, such as didodecyl benzene, can be used. Useful synthetic esters include the esters of monocarboxylic acids and polycarboxylic acids, as well as mono-hydroxy alkanols and polyols. Typical examples are didodecyl adipate, pentaerythritol tetracaproate, di-2-ethylhexyl adipate, dilaurylsebacate, and the like. Complex esters prepared from mixtures of mono and dicarboxylic acids and mono and dihydroxy alkanols can also be used. Blends of mineral oils with synthetic oils are also useful. The base oil usually has a viscosity measured at 100°C in the range of about 1 to 50 cSt.

Alkali Metal Borates

[0024] Alkali metal borates or hydrates thereof are well known in the art and are available commercially. Examples of the alkali metal borates or hydrates thereof include potassium borate hydrate and sodium borate hydrate represented by KB<sub>3</sub>O<sub>5</sub>·H<sub>2</sub>O and NaB<sub>3</sub>O<sub>5</sub>·H<sub>2</sub>O, respectively. These alkali metal borate hydrates are, for example, prepared by the steps of dissolving potassium (or sodium) hydroxide and boric acid in water so that the atomic ratio of boron to alkali metal (potassium or sodium) would be in the range of 2.0 to 4.5 (boron/alkali metal), dispersing the solution in an oily solution containing a neutral alkaline earth metal sulfonate or an ashless dispersant of succinic imide type, and allowing it to react to obtain the desired hydrate in the form of a dispersion liquid of fine particles.

[0025] The gear lubricating oil composition of the invention comprises the alkali metal borate or hydrate thereof in an amount of 0.04 to 1.0 wt % in terms of boron content, preferably 0.05 to 0.6 wt %, more preferably 0.08 to 0.5 wt%. This amount corresponds to about 0.6 to 15 wt % of alkali metal borate or hydrate thereof in the lubricating oil composition, if OLOA9750 (dispersion liquid of potassium borate hydrate, commercially available from Oronite Japan, Ltd., boron content: 6.8 wt %) or OLOA312 (dispersion liquid of potassium borate hydrate, commercially available from Oronite Japan, Ltd., boron content: 6.9 wt %) is used.

Oil-Soluble Sulfur-Containing Extreme Pressure Agent

[0026] Examples of the oil-soluble sulfur-containing extreme pressure agents include polyolefin sulfide (e.g., polyisobutylene sulfide), sulfurized fat and polysulfide. Further, various oil-soluble sulfur-containing extreme pressure agents described in the aforementioned publications in the BACKGROUND OF THE INVENTION are also employable. The oil-soluble sulfur-containing extreme pressure agents can be used singly or in combination of two or more.

[0027] The gear lubricating oil composition of the present invention comprises the oil-soluble sulfur-containing extreme pressure agent in an amount of 0.01 to 5.0 wt % in terms of sulfur content. This amount corresponds to about 0.02 to 11 wt % of the oil-soluble sulfur-containing extreme pressure agent, if Mobilad C100 (solution of polyisobutylene sulfide, commercially available from Mobil Chemical Co., sulfur content: 47 wt %) is used.

Oil-Soluble Phosphorus-Containing Extreme Pressure Agent

[0028] Examples of the oil-soluble phosphorus-containing extreme pressure agents include esters prepared from phosphorous acid and aliphatic or aromatic alcohols (e.g., dilauryl phosphite, diphenyl phosphite, dioleoyl phosphite, monobutyl phosphite, dibutyl phosphite) and esters prepared from phosphoric acid and aliphatic or aromatic alcohols (e.g., mono-octyl phosphate, dioctyl phosphate, trioctyl phosphate). Further, various oil-soluble phosphorus-containing extreme pressure agents described in the aforementioned publications in the BACKGROUND OF THE INVENTION are also employable. The oil-soluble phosphorus-containing extreme pressure agents can be used singly or in combination of two or more. The oil-soluble phosphorus-containing extreme pressure agents may contain alkylamines (e.g., oleylamine, laurylamine) for neutralization.

[0029] The gear lubricating oil composition of the present invention comprises the oil-soluble phosphorus-containing extreme pressure agent in an amount of 0.001 to 1.0 wt % in terms of phosphorus content. This amount corresponds to about 0.01 to 16 wt % of the oil-soluble phosphorus-containing extreme pressure agent, if JP212 (solution of dilauryl phosphite, commercially available from Johoku Chemical Co. Ltd., phosphorus content: 6.5 wt %) is used.

[0030] Instead of using both of the oil-soluble sulfur-containing extreme pressure agent and the oil-soluble phosphorus-containing extreme pressure agent, an oil-soluble phosphorus/sulfur-containing extreme pressure agent (e.g., di-

n-hexyldithiophosphate), which has both phosphorus and sulfur together, may be used. In that case, the amount of the oil-soluble phosphorus/sulfur-containing extreme pressure agent corresponds to the total of the above-mentioned amounts of the oil-soluble sulfur-containing extreme pressure agent and the oil-soluble phosphorus-containing extreme pressure agent.

#### Zinc Dialkyldithiophosphate

[0031] The zinc dialkyldithiophosphate preferably has a straight- or branched-chain alkyl group such as butyl, hexyl, octyl, decyl, dodecyl, tetradecyl or hexadecyl. The zinc dialkyldithiophosphate is preferably contained in an amount of 0.01 to 1.0 wt % in terms of phosphorus content. This amount corresponds to about 0.1 to 14 wt % of the zinc dialkyldithiophosphate, if OLOA269R (dispersion liquid of zinc diprimaryalkyldithiophosphate, commercially available from Oronite Japan, Ltd., phosphorus content: 7.4 wt %) is used.

#### The Gear Lubricating Oil Composition

[0032] The gear lubricating oil composition of the present invention is useful in a method of improving the high temperature antiwear performance of gears. In that method, the gear lubricating oil composition of the present invention is used to lubricate gears.

[0033] The gear lubricating oil composition of the present invention can be prepared by successively or simultaneously adding the additive components to a base oil of lubricating viscosity, or by beforehand preparing a gear oil additive concentrate, as herein described below, and then mixing it with a base oil of lubricating viscosity.

[0034] In a further embodiment, a gear lubricating oil composition is produced by blending a mixture of the above components. The gear lubricating oil composition produced by that method might have a slightly different composition than the initial mixture, because the components may interact. The components can be blended in any order and can be blended as combinations of components.

#### Gear Oil Additive Concentrate

[0035] The gear oil additive concentrate of the present invention usually includes the product produced by blending:

- a) 3 to 20 wt % of an organic liquid diluent,
- b) 0.2 to 5.0 wt %, preferably 0.5 to 3.0 wt %, in terms of boron content of an alkali metal borate or hydrate thereof,
- c) 0.1 to 25.0 wt % in terms of sulfur content of an oil-soluble sulfur-containing extreme pressure agent,
- d) 0.01 to 5.0 wt % in terms of phosphorus content of an oil-soluble phosphorus-containing pressure agent, and
- e) 0.1 to 5.0 wt % in terms of phosphorus content of a zinc dialkyldithiophosphate.

[0036] The concentrates contain sufficient organic liquid diluent to make them easy to handle during shipping and storage. Typically, the concentrate will contain from 3 to 20 wt % of the organic liquid diluent, preferably 5 to 10 wt %.

[0037] Suitable organic diluents which can be used include, for example, solvent refined 100N, i.e., Cit-Con 100N, and hydrotreated 100N, i.e., Chevron 100N, and the like. The organic diluent preferably has a viscosity of about from 1.0 to 20 cSt at 100°C.

[0038] The components of the gear oil additive concentrate can be blended in any order and can be blended as combinations of components. The concentrate produced by blending the above components might be a slightly different composition than the initial mixture because the components may interact.

#### Other Additives

[0039] The following additive components are examples of some of the components that can be favorably employed in the present invention. These examples of additives are provided to illustrate the present invention, but they are not intended to limit it.

[0040] Examples of the other additive components include (alkaline or neutral) metal detergents such as sulfonates, phenates and salicylates of alkaline earth metals; ashless detergents such as alkenylsuccinimide; oxidation inhibitors such as phenol compounds and amine compounds; defoaming agents such as dimethylpolysiloxane and polyacrylate; friction modifiers such as higher fatty acids, higher alcohols, aliphatic amines, fatty acid amides, esters of fatty acids,

sulfurized fats, acidic phosphate esters, acidic phosphite esters, organic molybdenum compounds, and solid lubricants; corrosion inhibitors such as benzotriazole and thiazole; viscosity index improvers (which may be active type having increased dispersability) such as acrylic polymer, methacrylic polymer and olefin copolymer; and pour point depressants such as acrylic polymer, methacrylic polymer, polybutene, polyalkylstyrene and polyvinylacetate.

## EXAMPLES

[0041] The invention will be further illustrated by the following examples, which set forth particularly advantageous specific embodiments of the present invention. While the examples are provided to illustrate the present invention, they are not intended to limit it.

### Example 1

#### Examples 1-2 and Comparison Examples 1-2

[0042] The following base oil and additive components were mixed in the amounts shown in Table 1 [unit: wt %; the values in parentheses () are contents of the elements (B: boron, S: sulfur and P: phosphorus) in the resultant composition], to prepare gear lubricating oil compositions.

- (1) Base oil (petroleum type base oil 100NL, 80W90; viscosity at 100°C: about 17 cSt),
- (2) Dispersion liquid of potassium borate hydrate (OLOA9750, commercially available from Oronite Japan, Ltd.; boron content: 6.8 wt %),
- (3) Solution of polyisobutylene sulfide (Mobilad C100, commercially available from Mobil Chemical Co.; sulfur content: 47 wt %),
- (4) Solution of dialauryl phosphite (JP212, commercially available from Johoku Chemical Co. Ltd.; phosphorus content: 6.5 wt %),
- (5) Dispersion liquid of zinc diprimaryalkyldithiophosphate (OLOA269R, commercially available from Oronite Japan, Ltd.; phosphorus content: 7.4 wt %), and
- (6) Other additive agents (containing ashless dispersants and defoaming agents).

[0043] In order to estimate the performance properties of the prepared gear lubricating oil compositions, wear tests were performed with a Falex Tester (ASTM 3233A) and a Shell 4-Ball Tester under the following conditions. During the tests, elevation of the oil temperature was measured. Further, the ISOT Test (test for evaluating oxidizing stability) was performed under severe thermal conditions to measure the viscosity increase of the gear oil.

[0044] The results are shown in Table 2. All of the gear lubricating oil compositions prepared in Examples 1-2 and Comparison Examples 1-2 were subjected to the test with the Falex Tester and the ISOT Test (test for evaluating oxidizing stability), but the test with the Shell 4-Ball Tester was applied to only the gear lubricating oil compositions of Example 1 and Comparison Example 1.

#### 1) Test with Falex Tester

Rotation rate of axis: 1,000 rpm  
Load: 136 kg  
Time for measuring the oil temperature:

- before the test,
- when the test started (when the test started immediately after the weight of 136 kg was loaded),
- 5 minutes after the test started,
- 10 minutes after the test started,
- 15 minutes after the test started, and
- 20 minutes after the test started.

#### 2) Test with Shell 4-Ball Tester

Rotation rate of axis: 1,800 rpm  
Load: 40 kg  
Time for measuring the oil temperature:



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- when the test started (when the test started immediately after the weight of 40 kg was loaded),
- 1 hour after the test started, and
- 2 hours after the test started.

### 3) ISOT Test (test for evaluating oxidizing stability)

Measurement of viscosity elevation

Temperature of testing: 180°C

Period of testing: 96 hours

Measurement:

The viscosity (cSt) when the test started was measured (at 100°C), and the viscosity (cSt) after heating for 96 hours was measured (at 100°C). From the measured viscosities, the rate of viscosity elevation was calculated.

Table 1

Components	Wt % of Components			
	Ex. 1	Ex. 2	Comp. Ex. 1	Comp. Ex. 2
Base Oil	92.40	85.40	95.35	94.90
Potassium Borate Hydrate	3.0	10.00	0.05	0.50
(B)	(0.204)	(0.680)	(0.003)	(0.034)
Polyisobutylene Sulfide	2.00	2.00	2.0	2.00
(S)	(0.940)	(0.940)	(0.940)	(0.940)
Dilauryl Phosphite	0.62	0.62	0.62	0.62
(P)	(0.040)	(0.040)	(0.040)	(0.040)
Zinc Diprimaryalkyl-dithiophosphate	1.00	1.00	1.00	1.00
(P)	(0.074)	(0.074)	(0.074)	(0.074)
Other Additive Agents	0.98	0.98	0.98	0.98

Table 2

	Ex. 1	Ex. 2	Comp. Ex. 1	Comp. Ex. 2
1) Test with Falex Tester				
before the test	24°C	24°C	24°C	24°C
when the test started	26°C	27°C	25°C	28°C
after 5 minutes	45°C	46°C	53°C	46°C
after 10 minutes	55°C	58°C	84°C	57°C
after 15 minutes	64°C	65°C	96°C	67°C
after 20 minutes	72°C	72°C	105°C	74°C
2) Test with Shell 4-Ball Tester				
when the test started	26°C	---	26°C	---
after 1 hour	72°C	---	74°C	---
after 2 hours	77°C	--	79°C	---
3) ISOT Test - viscosity (cSt)				
when the test started	16.89	16.82	16.85	16.77
after 96 hours	36.36	33.21	>20,000	>20,000
viscosity elevation rate	215%	197%	> 1,187%	> 1,193%

**[0045]** The results in Table 2 indicate that the temperature of the gear oil (lubricating oil) hardly increases when the gear lubricating oil composition of the present invention is used, even while the gears are working under severe conditions. Further, the results also show that the viscosity of the gear lubricating oil composition of the present invention increases only slightly after running at a high temperature for 96 hours. Accordingly, the gear lubricating oil composition

of the present invention provides improved high temperature stability of the gear oil and hence improved antiwear performance.

### Example 3

**[0046]** A gear oil additive concentrate was prepared from the additive components described in Example 1. The gear oil additive concentrate comprises the following components:

- (1) An organic liquid diluent,
- (2) Dispersion liquid of potassium borate hydrate: 39.47 wt % (boron content in the additive composition: 2.68 wt %),
- (3) Solution of polyisobutylene sulfide: 26.32 wt % (sulfur content in the additive composition: 12.37 wt %),
- (4) Solution of dilauryl phosphite: 8.16 wt % (phosphorus content in the additive composition: 0.53 wt %),
- (5) Dispersion liquid of zinc diprimaryalkyldithiophosphate: 13.16 wt % (phosphorus content in the additive composition: 1.00 wt %), and
- (6) Other additive agent: 12.89 wt %.

**[0047]** The gear lubricating oil composition of the present invention has excellent properties as a gear oil, particularly as a lubricating oil composition for gears of motor cars. In particular, even if the composition of the present invention is continuously used for a long time, its temperature increases only slightly. Therefore, the present invention can be effectively used as a gear oil with improved stability and ensures that gears work for long periods of time without failure.

### Claims

1. A gear lubricating oil composition comprising:

- a) a major amount of a base oil of lubricating viscosity,
- b) 0.04 to 1.0 wt % in terms of boron content of an alkali metal borate or hydrate thereof,
- c) 0.01 to 5.0 wt % in terms of sulfur content of an oil-soluble sulfur-containing extreme pressure agent,
- d) 0.001 to 1.0 wt % in terms of phosphorus content of an oil-soluble phosphorus-containing extreme pressure agent, and
- e) 0.01 to 1.0 wt % in terms of phosphorus content of a zinc dialkyldithiophosphate.

2. The gear lubricating oil composition of Claim 1 wherein the amount of said alkali metal borate or hydrate thereof is in the range of 0.05 to 0.6 wt % in terms of boron content.

3. The gear lubricating oil composition of Claim 1 wherein the amount of said alkali metal borate or hydrate thereof is in the range of 0.08 to 0.5 wt % in terms of boron content.

4. The gear lubricating oil composition of Claim 1, wherein the boron content of said alkali metal borate or hydrate thereof is not less than 1/10 by weight, based on the sulfur content, of said oil-soluble sulfur-containing extreme pressure agent.

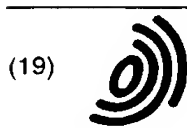
5. A gear oil additive concentrate comprising:

- a) 3 to 20 wt % of an organic liquid diluent,
- b) 0.2 to 5.0 wt % in terms of boron content of an alkali metal borate or hydrate thereof,
- c) 0.1 to 25.0 wt % in terms of sulfur content of an oil-soluble sulfur-containing extreme pressure agent,
- d) 0.01 to 5.0 wt % in terms of phosphorus content of an oil-soluble phosphorus-containing pressure agent, and
- e) 0.1 to 5.0 wt % in terms of phosphorus content of a zinc dialkyldithiophosphate.

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6. The gear oil additive concentrate of Claim 5, wherein the amount of said alkali metal borate or hydrate thereof is in the range of 0.5 to 3.0 wt % in terms of boron content.
7. The gear oil additive concentrate of Claim 5, wherein the boron content of said alkali metal borate or hydrate thereof is not less than 1/10 by weight based on the sulfur content of oil-soluble sulfur-containing extreme pressure agent.
8. The gear oil additive concentrate of Claim 6, wherein said oil-soluble sulfur-containing extreme pressure agent comprises polyolefin sulfide.
9. A method of producing a gear lubricating oil composition comprising blending the following components together:
- a) a major amount of a base oil of lubricating viscosity,
  - b) 0.04 to 1.0 wt % in terms of boron content of an alkali metal borate or hydrate thereof,
  - c) 0.01 to 5.0 wt % in terms of sulfur content of an oil-soluble sulfur-containing extreme pressure agent,
  - d) 0.001 to 1.0 wt % in terms of phosphorus content of an oil-soluble phosphorus-containing extreme pressure agent, and
  - e) 0.01 to 1.0 wt % in terms of phosphorus content of a zinc dialkyldithiophosphate.
10. A method of improving the high temperature, antiwear performance of gears, said method comprising lubricating said gears with the gear lubricating oil composition of Claim 1.





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(12) **EUROPEAN PATENT APPLICATION**

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(54) **Gear lubricating oil composition**

(57) A gear lubricating oil composition comprising a base oil of lubricating viscosity having dissolved or dispersed therein an alkali metal borate or a hydrate thereof in an amount of 0.04 to 1.0 wt % in terms of boron content, an oil-soluble sulfur-containing extreme pres-

sure agent in an amount of 0.01 to 5.0 wt % in terms of sulfur content, an oil-soluble phosphorus-containing extreme pressure agent in an amount of 0.001 to 1.0 wt % in terms of phosphorus content, and a zinc dialkyldithiophosphate in an amount of 0.01 to 1.0 wt % in terms of phosphorus content.

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## EUROPEAN SEARCH REPORT

Application Number

EP 00 30 4671

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The present search report has been drawn up for all claims			
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>28 November 2000</b>	Examiner <b>Rotsaert, L</b>
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone  Y : particularly relevant if combined with another document of the same category  A : technological background  O : non-written disclosure  P : intermediate document</p> <p>T : theory or principle underlying the invention  E : earlier patent document, but published on, or after the filing date  D : document cited in the application  L : document cited for other reasons</p> <p>&amp; : member of the same patent family, corresponding document</p>			

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